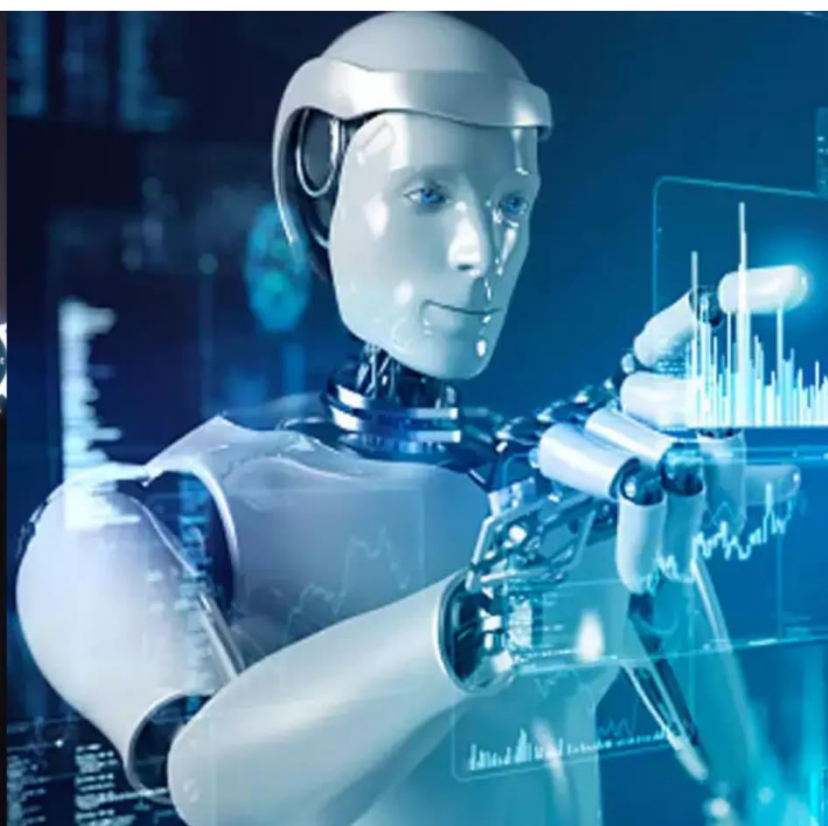




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Grid Connected Electric Vehicle Charging Station using PV Source

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ABSTRACT: This paper presents an electric vehicle charging station powered by three sources: the power grid, a photovoltaic system (PVS), and a battery energy storage system (BES), designed to operate in both onshore and offshore conditions. The power grid, equipped with an AC/DC converter, delivers continuous and stable power to the EV charging station via DC/DC converters. The BES acts as a buffer, storing surplus energy during light load conditions and supplying it as needed. A control unit manages the bi-directional DC/DC converter for both charging and discharging operations. The maximum power point tracking (MPPT) technique is employed to generate optimal pulses for the DC/DC converter, ensuring maximum power extraction from the PVS under varying conditions. The proposed system is simulated using MATLAB/SIMULINK, and the results are analyzed to validate its performance.

KEYWORDS: Robotics, Fire extinguishing, Fire accidents, Human safety, Internet of Things (IoT)

I. INTRODUCTION

The increasing human population and rapid Carbon emissions from internal combustion engine (ICE) vehicles significantly contribute to environmental pollution. Replacing ICE vehicles with electric vehicles (EVs) offers numerous advantages, including improved energy efficiency, cost-effectiveness, and most importantly, environmental benefits. Unlike ICE vehicles, EVs do not emit harmful greenhouse gases or particulate matter, thus contributing to better air quality and environmental sustainability [1].

Globally, many countries are adopting EVs at a large scale as an alternative to ICE vehicles, with this trend steadily increasing [2]. In India, the government has launched various initiatives and set ambitious targets to promote EV adoption. These include the National Electric Mobility Mission (2012), which aimed to deploy 5 to 7 million EVs by 2020, and the Faster Adoption and Manufacturing of Electric Vehicles (FAME) scheme (2015), focused on reducing EV costs. Additionally, projects for developing charging infrastructure have been implemented, and in 2017, a policy was announced to phase out fossil fuel vehicles by 2030 [3].

EVs rely on electricity stored in batteries as their primary energy source. When the battery discharges, EVs need to be recharged, necessitating the availability of EV charging stations. These stations require a reliable and continuous power supply for uninterrupted operation. While the electric grid can be used for this purpose, it poses challenges in handling increased load demand and offers limited environmental benefits if powered by conventional energy sources [4].

Renewable energy sources, particularly solar energy, present a viable solution to these challenges. Solar energy is not only renewable but also environmentally friendly. Integrating EV charging stations with renewable energy sources is a sustainable approach that should be widely adopted to enhance environmental conservation.

II. LITERATURE SURVEY

The integration of grid-connected solar-powered charging stations for electric vehicles (EVs) has been widely explored in literature, focusing on the environmental, technical, and economic benefits. [1]. Studies highlight the potential of solar energy to reduce greenhouse gas emissions and reliance on fossil fuels, while also addressing grid stress by

locally generating power. Key technologies such as smart grids, battery storage systems, and vehicle-to-grid (V2G) integration are central to enhancing the reliability, efficiency, and scalability of these stations.[2]. Research also emphasizes the economic viability through mechanisms like net metering, although challenges such as high initial costs and land requirements persist. [3], [4].

The integration of solar power with electric vehicle (EV) charging infrastructure has been a subject of significant research over the past decade. Studies have consistently highlighted the potential of solar-powered charging stations to reduce greenhouse gas emissions and decrease reliance on non-renewable energy sources. [5]. Grid-connected systems, in particular, have gained attention for their ability to combine renewable energy generation with the reliability of grid electricity, addressing the challenges of solar energy intermittency.

[6].Khalid Yahya, Mahmoud Mohamed and Mohamad karmarol -They conducted review on integration of EV charging with solar Photovoltaic (PV) Systems.The paper reviews the integration of EV charging with solar PV systems. It covers technical, economic, and environmental aspects of such systems. The authors discuss challenges, benefits, and case studies of successful integrations. The review provides a comprehensive overview of the current state of knowledge. It highlights the potential for such systems to support a low-carbon transportation sector. The integration of EV charging with solar PV systems can reduce greenhouse gas emissions.

[7].A.R.H.K., and S.M. conducted the review on Renewable Energy integration in EV charging comparing grid only , PV grid and PV-BESS(battery energy storage systems). A.R., H.K., and S.M. conducted a review on Renewable Energy integration in EV charging.The review compared three scenarios: grid-only, PV-grid, and PV-BESS. The study evaluated the benefits and challenges of each scenario. The PV-BESS scenario showed the most promising results, offering improved efficiency and reduced emissions. The review highlights the potential of Renewable Energy integration in EV charging for a sustainable transportation sector.

[8].Ahmed Elsanabary, Karam Khairullah, Nur Fadilah Ab Aziz, and Saad Mekhilef conducted a review on power management and optimized control of hybrid PV-BESS-grid integrated fast EV charging. Their study focused on optimizing the performance of hybrid systems that combine photovoltaic (PV) power, battery energy storage systems (BESS), and grid integration for fast electric vehicle (EV) charging. The review aimed to improve the efficiency and reliability of hybrid PV-BESS-grid systems, which are crucial for widespread adoption of fast EV charging. By optimizing power management and control strategies, the researchers sought to minimize energy losses, reduce costs, and enhance the overall performance of these systems.

III. PROBLEM STATEMENT

The rapid growth in electric vehicle (EV) adoption has created an urgent need for efficient and sustainable charging infrastructure. Conventional charging stations rely heavily on grid electricity, often sourced from fossil fuels, which undermines the environmental benefits of EVs by contributing to greenhouse gas emissions and energy resource depletion. Additionally, the increasing energy demand from EVs places significant stress on the electrical grid, particularly during peak hours, leading to potential instability and higher operational costs.

Moreover, existing charging solutions lack integration with renewable energy sources, resulting in missed opportunities to harness clean and abundant solar energy. The absence of a widespread, sustainable charging network limits the scalability of EV adoption, particularly in urban areas striving for greener transportation systems. This highlights the need for a grid-connected solar-powered charging station that addresses these challenges by combining renewable energy with grid reliability, ensuring sustainable, efficient, and cost-effective EV charging solutions.

The increasing adoption of electric vehicles (EVs) as a sustainable alternative to conventional internal combustion engine vehicles has created a growing demand for efficient and environmentally friendly charging infrastructure. However, traditional EV charging stations predominantly rely on grid electricity, which is often generated from fossil fuels. This dependency negates some of the environmental benefits of EVs, contributing to greenhouse gas emissions and overburdening the existing power grid.

Solar-powered charging stations present a sustainable solution but face challenges such as energy intermittency, high initial costs, and reliance on battery storage. Fully off-grid systems are also limited in scalability and reliability, as they are unable to meet energy demand consistently during periods of low solar energy availability.

The need arises for a hybrid solution: a grid-connected solar-powered charging station that can seamlessly integrate renewable energy generation with grid support. This approach must address issues such as energy management, efficient utilization of solar power, and grid integration while providing a reliable and cost-effective charging infrastructure for EVs. Developing such a system is essential to support the widespread adoption of EVs, reduce environmental impact, and promote the transition to a renewable energy future.

IV. OBJECTIVES

The main objective of present study is to develop the Grid Connected Solar Powered Charging Station for EV. However, the specific objectives are as follows.

- Design and implementation of solar grid panel.
- Design and implementation of MPPT controller for DC booster for generating solar output.
- Design and implementation of INVERTER for DC to AC converter using full bridge rectifier.
- Design and implementation of grid storage for generated data with EV load.

V. METHODOLOGY

The methodology for designing and implementing a grid-connected solar-powered charging station for electric vehicles (EVs) involves a systematic and structured approach to ensure its technical feasibility, economic viability, and operational efficiency. Here in this project we used MATLAB Software:

MATLAB (Matrix Laboratory) is a high-performance software environment widely used for numerical computation, visualization, and programming. Developed by MathWorks, MATLAB provides an intuitive interface for solving complex mathematical problems, designing algorithms, and analyzing data. Its strength lies in its extensive library of toolboxes and functions that support diverse applications, including signal processing, control systems, machine learning, image processing, and computational finance. MATLAB's programming language allows users to write scripts and functions for automating tasks, while its graphical capabilities facilitate data visualization and interactive analysis. Popular among engineers, researchers, and scientists, MATLAB is also integrated with Simulink, a platform for model-based design, making it indispensable for simulation and control system development. Its user-friendly environment and ability to interface with other programming languages further enhance its versatility in academic and industrial applications.

MATLAB's versatility and ease of use have made it a standard tool in both academia and industry. It offers an extensive range of built-in functions and specialized toolboxes for various disciplines, such as control systems, signal processing, neural networks, robotics, and image processing. Its ability to handle large datasets and perform complex mathematical operations efficiently makes it ideal for tasks ranging from basic data analysis to advanced simulations. MATLAB's interactive environment allows users to visualize data in multiple formats, enabling a better understanding of trends and patterns, which is particularly useful for research and development projects.

Moreover, MATLAB supports integration with other programming languages like Python, C, C++, and Java, making it a highly flexible tool in multi-language environments. It also offers compatibility with hardware platforms, allowing users to interface MATLAB with sensors, microcontrollers, and embedded systems for real-world applications. Additionally, the platform's support for parallel computing and GPU acceleration ensures that computationally intensive tasks are handled efficiently. MATLAB's robust documentation, active user community, and extensive learning resources make it accessible for both beginners and advanced users, solidifying its position as a go-to tool for engineers, data scientists, and researchers worldwide.

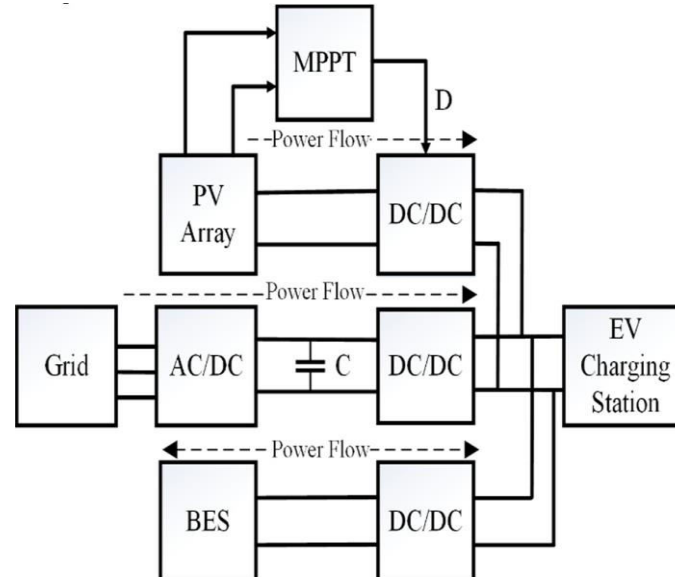


Fig. 1: Block Diagram of Grid Connected Electric Vehicle Charging Station Using PV Source

The block diagram of grid connected electric vehicle charging station using PV source is shown in Fig.1. It provides an overall view of the system's architecture. The components connected in this system include PV array, MPPT, Chopper(DC/DC), Inverter(DC/AC), BES, Grid.

VI. RESULT

MATLAB is a powerful simulation software widely used for modelling, analyzing, and designing engineering systems, including renewable energy systems like grid-connected solar-powered EV charging stations. In MATLAB/Simulink, users can create dynamic models of solar panels, inverters, battery systems, and grid connections to study their behaviour under various conditions.

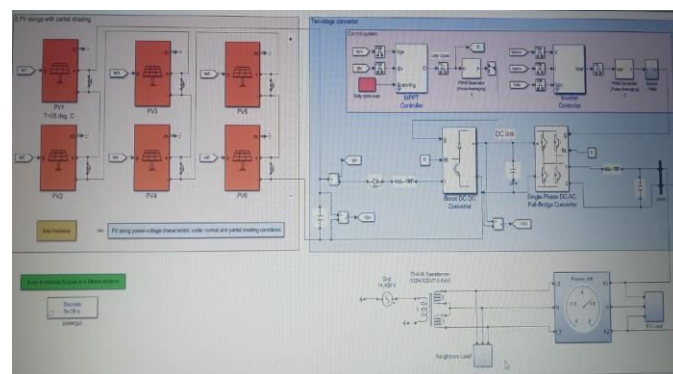


Fig.2. Grid connected charging station using pv array simulation using SIMULINK.

The software provides a modular environment where each component, such as PV arrays, MPPT controllers, or inverters, is represented by predefined blocks that can be customized for specific parameters. Using MATLAB, users can simulate power flow, monitor system efficiency, and analyze voltage and current waveforms, helping to evaluate the performance of the charging station. MATLAB also enables integration of advanced control algorithms, such as Maximum Power Point Tracking (MPPT) and grid synchronization techniques, ensuring system reliability and optimal energy utilization.

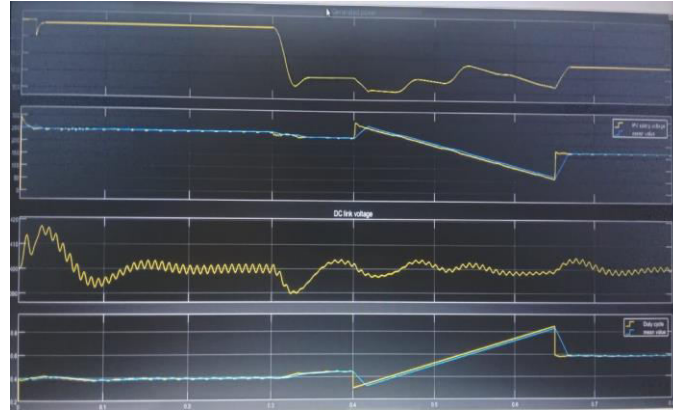


Fig.3. Output Waveforms

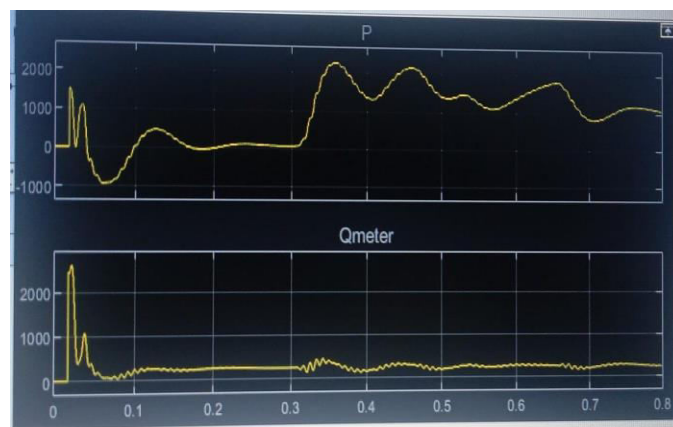


Fig.4. PQ Meter Waveform

VII. CONCLUTIONS

The integration of grid-connected solar-powered electrical vehicles represents a significant step towards a sustainable transportation future. This innovative approach combines the benefits of renewable energy, energy efficiency, and reduced greenhouse gas emissions. By harnessing solar energy to power electrical vehicles, we can significantly reduce our reliance on fossil fuels and mitigate climate change.

The grid-connected solar-powered electrical vehicle system offers numerous advantages, including reduced energy costs, increased energy independence, and improved air quality. Additionally, this system enables the efficient use of renewable energy, reduces the strain on the grid, and provides a reliable and resilient energy supply.

The widespread adoption of grid-connected solar-powered electrical vehicles can have a profound impact on the environment, the economy, and society as a whole. By promoting the use of renewable energy, reducing greenhouse gas emissions, and improving air quality, we can create a more sustainable and livable future for generations to come. Furthermore, the integration of grid-connected solar-powered electrical vehicles can also provide economic benefits, such as creating jobs, stimulating local economies, and reducing energy costs. Additionally, this system can enhance energy security, reduce dependence on imported fuels, and promote energy self-sufficiency.

However, there are also challenges associated with the widespread adoption of grid-connected solar-powered electrical vehicles, such as the high upfront costs, infrastructure requirements, and energy storage needs. Nevertheless, these challenges can be addressed through innovative solutions, policy support, and investment in research and development.

In conclusion, the integration of grid-connected solar-powered electrical vehicles represents a critical step towards a sustainable transportation future. By harnessing the power of renewable energy, reducing greenhouse gas emissions, and promoting energy efficiency, we can create a more sustainable, resilient, and livable future for all.

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